



US012026691B2

(12) **United States Patent**  
**Chatterjee et al.**

(10) **Patent No.:** **US 12,026,691 B2**

(45) **Date of Patent:** **Jul. 2, 2024**

(54) **COMPUTING DISTANCES OF DEVICES**

(56) **References Cited**

(71) Applicant: **Block, Inc.**, San Francisco, CA (US)

U.S. PATENT DOCUMENTS

(72) Inventors: **Shuvo Chatterjee**, San Francisco, CA (US); **Michael Thole**, Portland, OR (US)

6,674,403 B2 1/2004 Gray et al.  
6,952,181 B2 10/2005 Karr et al.  
(Continued)

(73) Assignee: **Block, Inc.**, Oakland, CA (US)

FOREIGN PATENT DOCUMENTS  
CA 2 953 125 A1 12/2015  
EP 1 542 492 A1 6/2005  
(Continued)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 497 days.

OTHER PUBLICATIONS

(21) Appl. No.: **16/413,971**

In search of reliable centimeter-level indoor positioning: a smartphone-based approach Alternate title: Desenvolvimento de metodologias para localização indoor de smartphones com exatidão ao centímetro Lopes, Sérgio Ivan Fernandes. Universidade de Aveiro (Portugal). ProQuest Dissertations Publishing, 2014. 105.\*

(22) Filed: **May 16, 2019**

(Continued)

(65) **Prior Publication Data**

US 2019/0325422 A1 Oct. 24, 2019

*Primary Examiner* — Florian M Zeender

*Assistant Examiner* — Fawaad Haider

(74) *Attorney, Agent, or Firm* — Lee & Hayes P.C.

**Related U.S. Application Data**

(63) Continuation of application No. 14/310,802, filed on Jun. 20, 2014, now Pat. No. 10,304,049.

(57) **ABSTRACT**

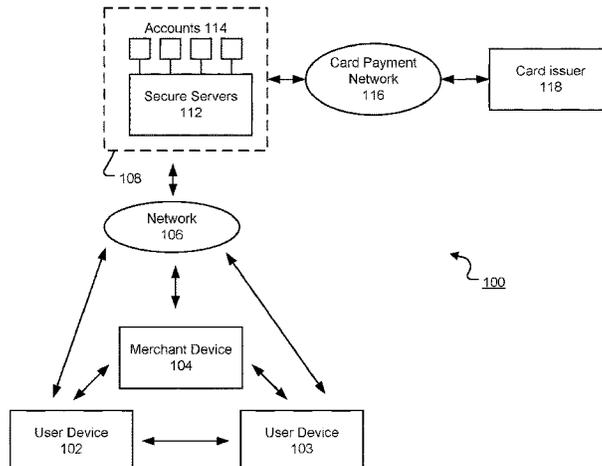
Methods and systems associated with facilitating transactions based on proximity between devices, the methods and systems including ranking distances between a first device and a plurality of other devices based on wireless signal strengths; presenting a representation of a first user of the first device on one of the first device or a second device based on the ranking when the distance between the first device and the second device satisfies a threshold; causing server(s) of a payment service system (PSS) to identify user accounts of the first user and/or a second user of the second device based on selection of the representation and a user identifier in a wireless signal transmitted by a transceiver of one of the devices; processing a transaction using stored payment data associated with the user account(s); and presenting an indication of the transaction on at least one of the devices.

(51) **Int. Cl.**  
**H04W 4/02** (2018.01)  
**G06Q 20/20** (2012.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **G06Q 20/327** (2013.01); **G06Q 20/20** (2013.01); **G06Q 20/202** (2013.01);  
(Continued)

(58) **Field of Classification Search**  
CPC ..... G06Q 30/06; G06Q 20/202; G06Q 20/20; G06Q 20/3278; G06Q 20/209; G06Q 20/327; G06Q 20/3224; H04W 4/023  
(Continued)

**20 Claims, 6 Drawing Sheets**



- (51) **Int. Cl.**  
*G06Q 20/32* (2012.01)  
*G06Q 30/06* (2023.01)  
*H04M 1/72454* (2021.01)  
*H04M 1/72457* (2021.01)
- (52) **U.S. Cl.**  
 CPC ..... *G06Q 20/209* (2013.01); *G06Q 20/3224*  
 (2013.01); *G06Q 20/3278* (2013.01); *G06Q*  
*30/06* (2013.01); *H04W 4/023* (2013.01);  
*H04M 1/72454* (2021.01); *H04M 1/72457*  
 (2021.01)
- (58) **Field of Classification Search**  
 USPC ..... 705/21  
 See application file for complete search history.

2015/0081348	A1	3/2015	Avera et al.
2015/0186803	A1	7/2015	Stong
2015/0186957	A1	7/2015	Barr et al.
2016/0021507	A1	1/2016	Gaines
2016/0095188	A1	3/2016	Verberkt et al.
2016/0148121	A1	5/2016	Durham et al.
2016/0180386	A1	6/2016	Konig
2016/0192149	A1	6/2016	Zises
2017/0169413	A1	6/2017	Holmes et al.
2021/0374703	A1	12/2021	Holmes et al.

FOREIGN PATENT DOCUMENTS

EP	2 725 380	A1	4/2014
EP	2 731 363	A1	5/2014
JP	2017-528686	A	9/2017
WO	2015/195890	A1	12/2015

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,484,151	B1	7/2013	Lookingbill
8,744,749	B2	6/2014	Gupta et al.
8,750,123	B1	6/2014	Alisawi
8,755,824	B1	6/2014	Wang et al.
9,247,447	B1	1/2016	Vivanco et al.
9,449,121	B2	9/2016	Marti
9,516,470	B1	12/2016	Scotfield et al.
9,582,797	B1	2/2017	Holmes et al.
9,691,088	B2	6/2017	Kim et al.
9,892,424	B2	2/2018	Abraham et al.
10,304,049	B2	5/2019	Chatterjee et al.
10,445,774	B2	10/2019	Reese et al.
2004/0203832	A1	10/2004	An
2005/0233748	A1	10/2005	Robinson et al.
2006/0022048	A1	2/2006	Johnson
2007/0042770	A1	2/2007	Yasui et al.
2008/0214203	A1	9/2008	Titli et al.
2009/0204449	A1	8/2009	Waytena et al.
2009/0228325	A1	9/2009	Simmons et al.
2009/0303204	A1	12/2009	Nasiri et al.
2010/0015994	A1	1/2010	Mcbride et al.
2010/0063854	A1	3/2010	Purvis et al.
2010/0087144	A1*	4/2010	Korenshtein ..... H04B 17/318 455/41.2
2011/0158187	A1	6/2011	Komamura et al.
2011/0238476	A1	9/2011	Carr et al.
2011/0250901	A1	10/2011	Grainger et al.
2011/0285591	A1	11/2011	Wong
2012/0303402	A1	11/2012	Koury
2013/0006847	A1*	1/2013	Hammad ..... G06Q 20/382 705/39
2013/0030931	A1*	1/2013	Moshfeghi ..... H04B 5/73 705/16
2013/0046463	A1	2/2013	Bengtson et al.
2013/0054130	A1	2/2013	Ye et al.
2013/0117695	A1	5/2013	Hammoud
2013/0229930	A1	9/2013	Akay et al.
2013/0254104	A1	9/2013	Fernandez
2013/0262231	A1	10/2013	Glasgow et al.
2013/0275305	A1	10/2013	Duplan
2013/0332208	A1	12/2013	Mehta
2014/0030982	A1*	1/2014	Cardona ..... G01S 5/14 455/67.11
2014/0040001	A1	2/2014	Harvey et al.
2014/0074705	A1	3/2014	Kimberg et al.
2014/0114780	A1	4/2014	Menefee et al.
2014/0149241	A1	5/2014	Neuneker et al.
2014/0162693	A1	6/2014	Wachter et al.
2014/0163934	A1	6/2014	Zhang et al.
2014/0179340	A1*	6/2014	Do ..... G01S 5/021 455/456.1
2014/0180960	A1	6/2014	Sagfors et al.
2014/0368601	A1	12/2014	deCharms
2015/0006706	A1	1/2015	Ellis et al.
2015/0038171	A1	2/2015	Uilecan et al.
2015/0039451	A1	2/2015	Bonfiglio

OTHER PUBLICATIONS

Kushki, Azadeh. A cognitive radio tracking system for indoor environments. University of Toronto (Canada) ProQuest Dissertations Publishing, 2008.\*

Laszlo, Mehes. The Development of a GPS Based RF Signal Strength Measurement System. Applied Mechanics and Materials; Zurich vol. 309, (Feb. 2013): 294. (Year: 2013).\*

Lin, Peng; Li, Qingbin; Fan, Qixiang; Gao, Xiangyou; Hu, Senying. a Real-Time Location-Based Services System Using WiFi Fingerprinting Algorithm for Safety Risk Assessment of Workers in Tunnels. Mathematical Problems in Engineering; New York vol. 2014. (Year: 2014).\*

Examiner Requisition for Canadian Patent Application No. 2,953,125, dated Sep. 10, 2020

Non-Final Office Action dated Sep. 22, 2020, for U.S. Appl. No. 15/441,909, of Holmes, J., et al., filed Feb. 24, 2017.

Notice of Allowance dated Feb. 22, 2021, for U.S. Appl. No. 15/441,909, of Holmes, J., et al., filed Feb. 24, 2017.

Locke, Phil. Cell Tower Triangulation -How It Works. Wrongful Convictions Blog. Published Jun. 1, 2012. Retrieved on Nov. 11, 2014. Retrieved from the internet: URL <<http://wrongfulconvictionsblog.org/2012/06/01/cell-tower-triangulation-how-it-works/>>. 4 pages.

Bulut, M.F., et al., "LineKing: Crowdsourced Line Wait-Time Estimation using Smartphones," Retrieved from the Internet URL: <http://www.cse.buffalo.edu/~demirbas/publications/lineking.pdf>, on Oct. 17, 2016, pp. 1-20.

Bullock, D.M., et al., "Automated Measurement of Wait Times at Airport Security," Transportation Research Record: Journal of Transportation Research Board, No. 2177, pp. 60-68 (Dec. 2010).

Ishikawa, T., et al., "Economic and Synergistic Pedestrian Tracking System for Indoor Environments," International Conference of Soft Computing and Pattern Recognition, pp. 522-527 (Dec. 4-7, 2009).

Vigna, B., "Tri-axial MEMS gyroscopes and Six Degree-of-Freedom Motion Sensors," MEMS and Sensors Group, Electron Devices Meeting (IEDM), 2011 IEEE International, dated Dec. 5, 2011, pp. 29.1.1-29.1.3.

Notice of Allowance dated Oct. 17, 2016, for U.S. Appl. No. 14/461,072, of Holmes, J., et al., filed Aug. 15, 2014.

Corrected Notice of Allowance dated Nov. 14, 2016, for U.S. Appl. No. 14/461,072, of Holmes, J., et al., filed Aug. 15, 2014.

Corrected Notice of Allowance dated Nov. 23, 2016, for U.S. Appl. No. 14/461,072, of Holmes, J., et al., filed Aug. 15, 2014.

Non-Final Office Action dated Jun. 28, 2017, for U.S. Appl. No. 14/310,802, of Chatterjee, S., et al., filed Jun. 20, 2014.

Examination Report No. 1 for Australian Patent Application No. 2015277086, dated Aug. 2, 2017.

Examiner's Requisition for Canadian Patent Application No. 2,953,125, dated Aug. 31, 2017.

Final Office Action dated Jan. 12, 2018, for U.S. Appl. No. 14/310,802, of Chatterjee, S., et al., filed Jun. 20, 2014.

English-language translation of Notification of Reasons for Refusal for Japanese Patent Application No. 2016-573568, dated Feb. 19, 2018.

(56)

**References Cited**

OTHER PUBLICATIONS

Advisory Action dated Mar. 20, 2018, for U.S. Appl. No. 14/310,802, of Chatterjee, S., et al., filed Jun. 20, 2014.

Advisory Action dated May 10, 2018, for U.S. Appl. No. 14/310,802, of Chatterjee, S., et al., filed Jun. 20, 2014.

Non-Final Office Action dated Jun. 12, 2018, for U.S. Appl. No. 14/310,802, of Chatterjee, S., et al., filed Jun. 20, 2014.

Examination Report No. 2 for Australian Patent Application No. 2015277086, dated Jul. 13, 2018.

Notice of Acceptance for Australian Patent Application No. 2015277086, dated Jul. 25, 2018.

Examiner Requisition for Canadian Patent Application No. 2,953,125, dated Aug. 7, 2018.

English-language translation of Notification of Reasons for Refusal for Japanese Patent Application No. 2016-573568, dated Sep. 21, 2018.

English-language translation of Decision to Grant for Japanese Patent Application No. 2016-573568, dated Oct. 29, 2018.

Notice of Allowance dated Jan. 18, 2019, for U.S. Appl. No. 14/310,802, Chatterjee, S., et al., filed Jun. 20, 2014.

Non-Final Office Action dated Mar. 1, 2019, for U.S. Appl. No. 15/441,909, of Holmes, J., et al., filed Feb. 24, 2017.

Examiner Requisition for Canadian Patent Application No. 2,953,125, dated Jul. 15, 2019.

International Search Report and Written Opinion for International Application No. PCT/US2015/036392, dated Sep. 17, 2015.

Extended European Search Report for European Patent Application No. 15808998.7, dated Jun. 2, 2017.

European Examination Report for European Patent Application No. 15808998.7, dated Aug. 19, 2019.

Final Office Action dated Sep. 13, 2019, for U.S. Appl. No. 15/441,909, of Holmes, J., et al., filed Feb. 24, 2017.

Non-Final Office Action dated Apr. 7, 2020, for U.S. Appl. No. 15/441,909, of Holmes, J., et al., filed Feb. 24, 2017.

Summons to attend Oral Proceedings for European Patent Application No. 15808998.7, mailed Apr. 6, 2020.

Summons to attend Oral Proceedings for European Patent Application No. 15808998.7, mailed Apr. 26, 2020.

\* cited by examiner

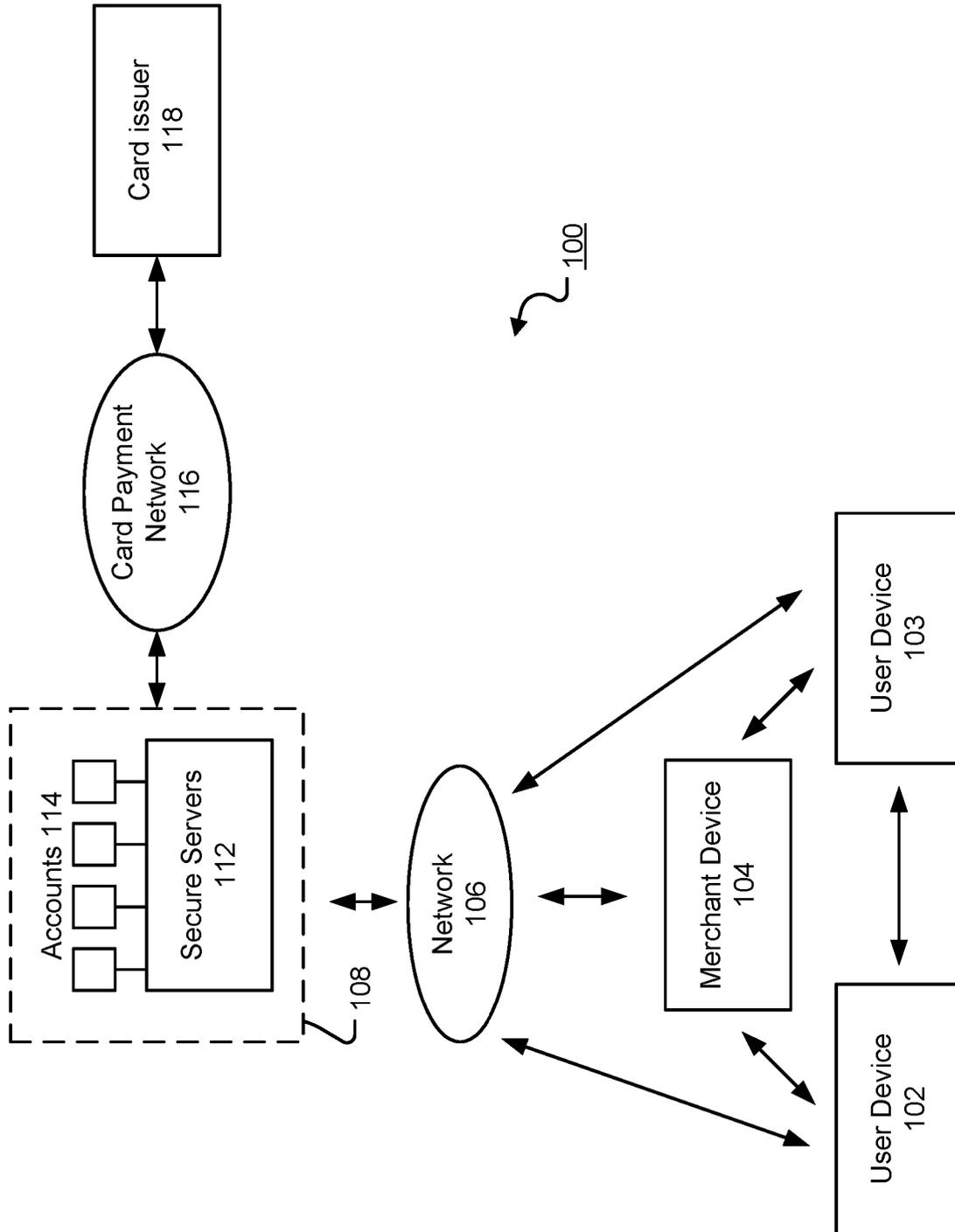


FIG. 1

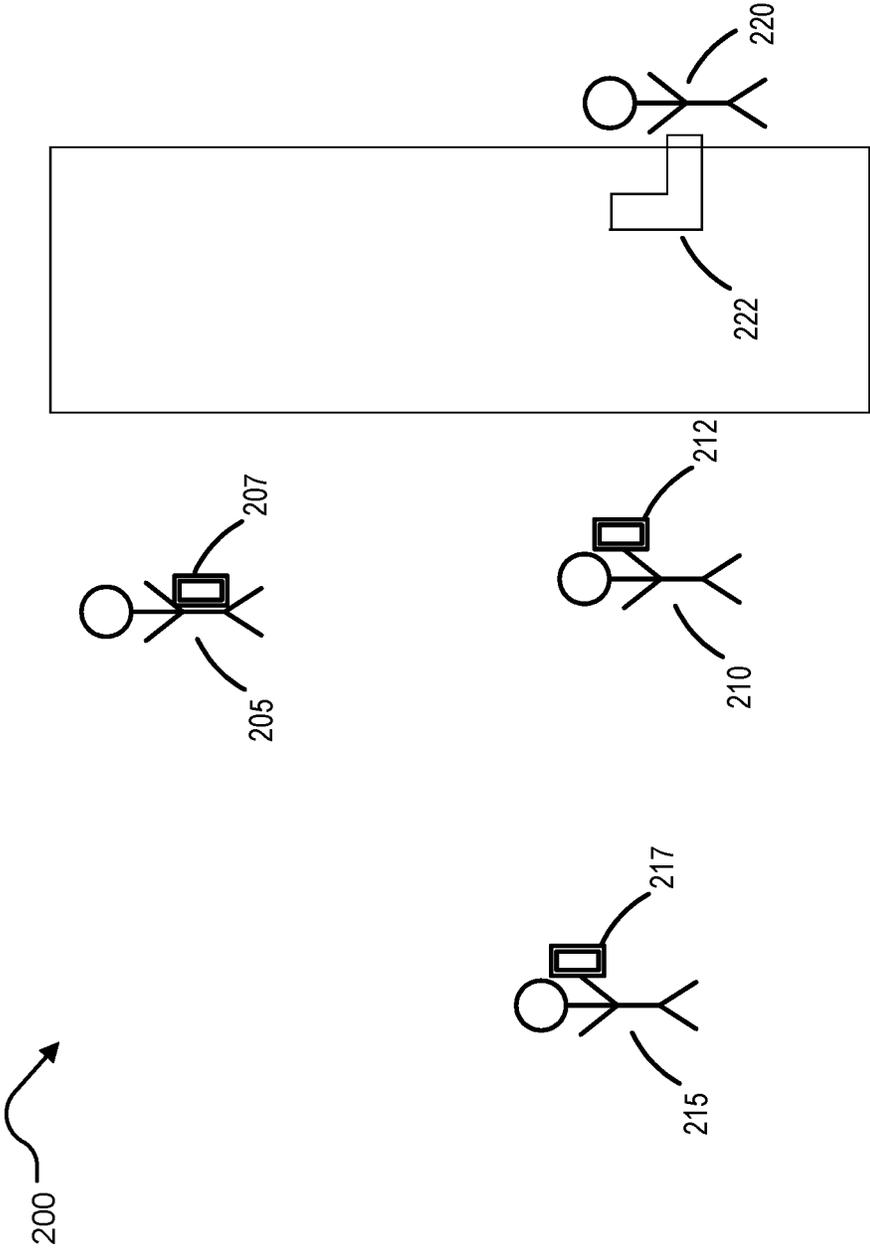


FIG. 2

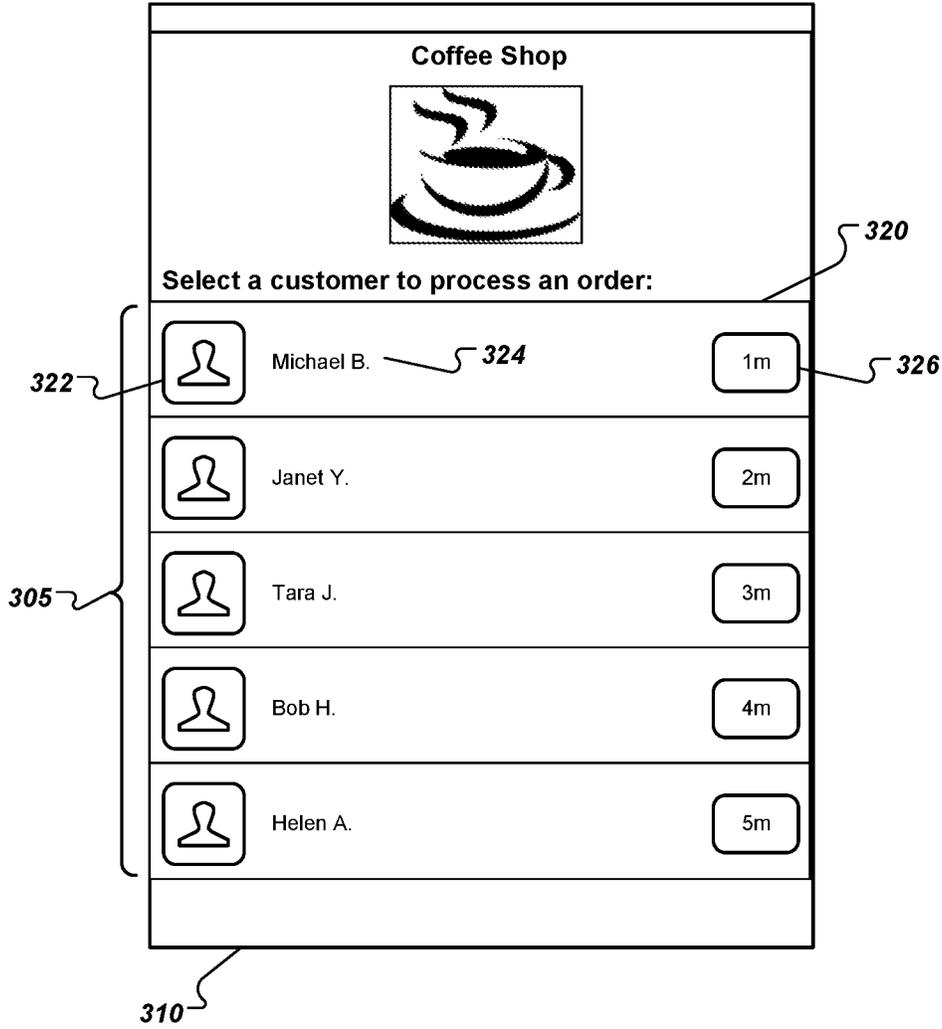


FIG. 3

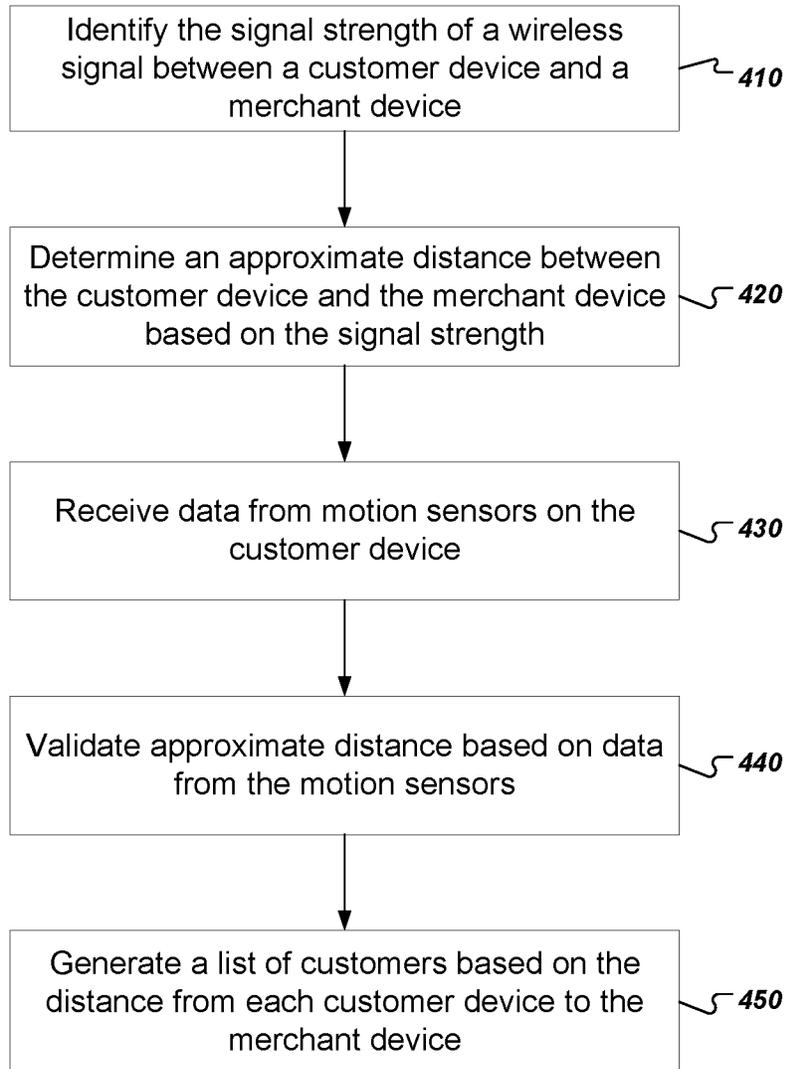


FIG. 4

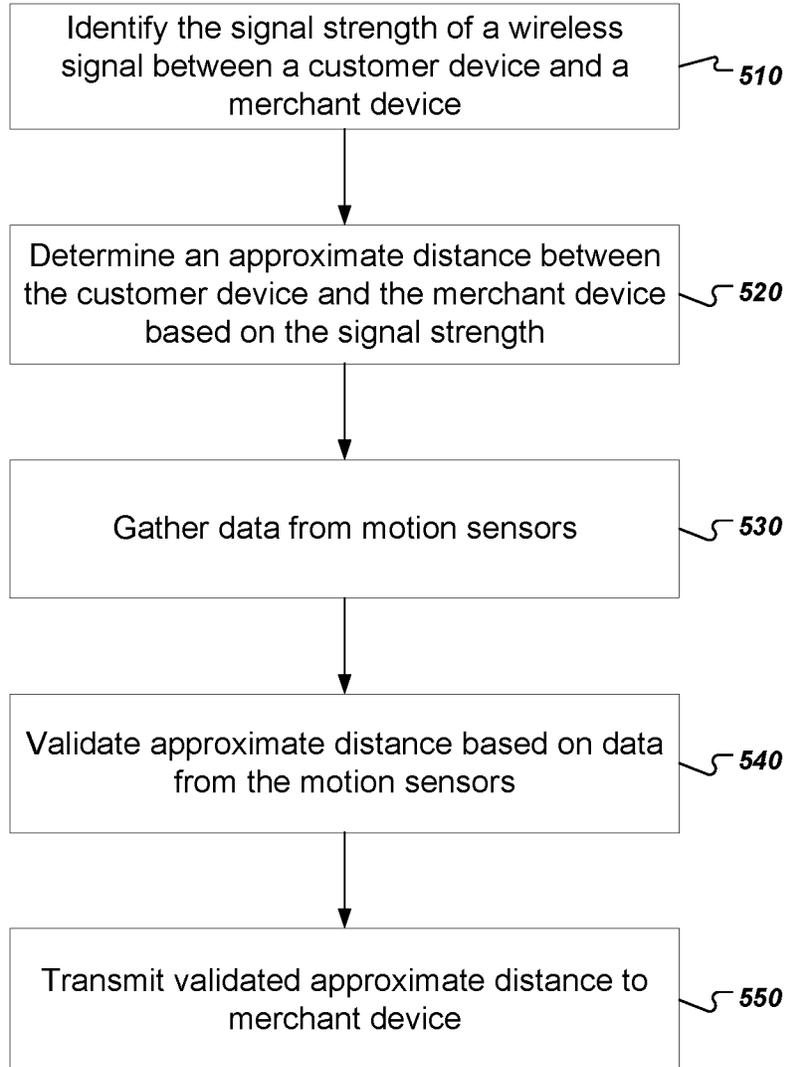


FIG. 5

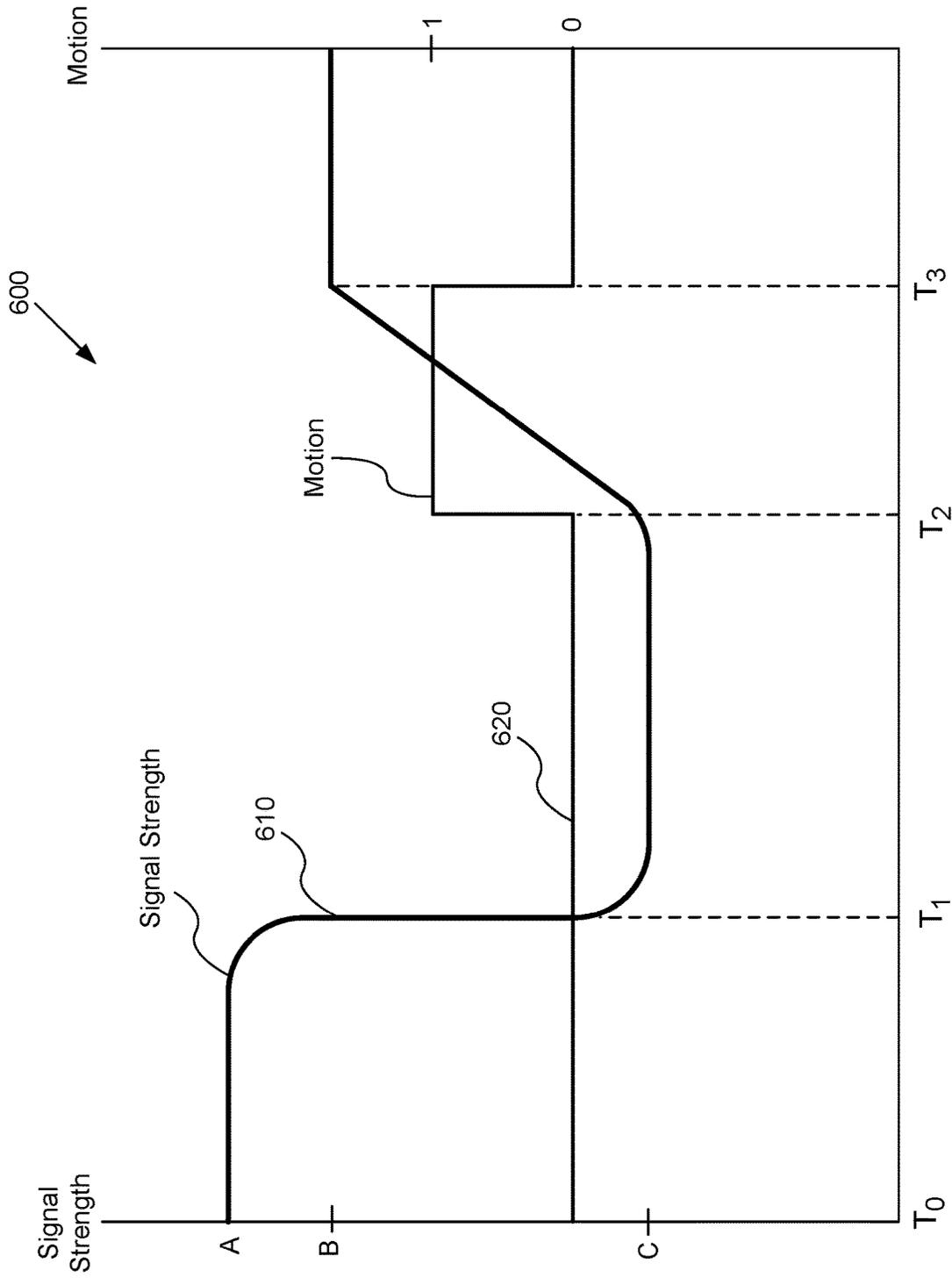


Fig. 6

## COMPUTING DISTANCES OF DEVICES

## PRIORITY

This application is a continuation of, and claims priority to, U.S. patent application Ser. No. 14/310,802, entitled “Computing Distances of Devices”, filed on Jun. 20, 2014, the entire contents of which are incorporated herein by reference.

## BACKGROUND

A measurement of radio signal strength, e.g. a Received Signal Strength Indicator (“RSSI”), can be used to estimate a distance of a device that is emitting the radio signal, e.g. a mobile device. Fixed radio receivers can also be used to triangulate a location of a mobile device. Mobile device locations can also be determined using Global Positioning System (GPS) signals.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration of the architecture of an example system.

FIG. 2 is a diagram that illustrates customers, each with a customer device, at a merchant’s place of business.

FIG. 3 is diagram of an example view of a user interface of an application installed on a merchant device.

FIGS. 4 and 5 are flow charts of an example processes for computing and validating distances between devices.

FIG. 6 is a diagram of an example graph of signal strength and motion data.

Like reference numbers and designations in the various drawings indicate like elements.

## DETAILED DESCRIPTION

A system can use radio signal strength measurements measured by a merchant device and/or radio signal strength measurements measured by mobile devices to compute a distance of each mobile device from a merchant device. The system can then use data from motion processors located in the mobile device to validate or adjust the computed distance. A merchant device can then display customer information arranged by distance from the merchant device to facilitate processing the orders of customers waiting in line.

In this specification, the radio signal strength measurement can include any appropriate indicator of radio signal strength, e.g. decibels, a signal to noise ratio, or RSSI, to name a few examples. The radio signals emitted by the user devices can be part of any appropriate standard for mid to short range radio signal communications, including NFC, Bluetooth, Bluetooth Low Energy, and other technologies with a range of less than one hundred meters. However, the techniques discussed below may work at any range.

The examples below will relate to computing distances between a merchant device and mobile devices that are participating in a cardless payment system. However, the techniques described are not limited to cardless payment systems, to calculating and validating distances from a merchant device, to ranking user devices by calculated and validated distances, or to systems that process payment transactions. Other systems can also compute and validate such distances of mobile devices from a reference computing device using measured radio signal strengths as measured by the mobile devices. In such systems the reference device takes the place of the merchant device. In addition,

the techniques described can be implemented by other systems capable of communicating over other wireless communication technologies having similar broadcast ranges.

A payment service system allows a user (also called a customer or payer) to purchase items from a merchant while physically present at the merchant, e.g., at the point of sale, or online, e.g. through a merchant’s website. Some payment service systems process cardless payment transactions. A cardless payment transaction is one where a user conducts the transaction with a merchant at a point of sale or online by using a financial account without physically presenting or otherwise providing information about a payment card to the merchant at the point of sale. In fact, the merchant need not receive any details about the financial account, e.g., the credit card issuer, credit card number, and the like is not provided to the merchant.

From the user’s perspective, the user first signs up for an account with the payment service system. The sign-up process requires certain information, such as information about a financial account sufficient to perform a transaction with the account. For example, if the financial account is a credit card account, then credit card information can be provided, e.g., credit card number and expiration date. The user can also sign up with other payment methods such as debit cards, pre-paid cards, bank accounts, or other third party financial accounts. The sign up process can also require contact information for the user, e.g., mailing address and email, and other personal identifying information, e.g., a photograph of the user. After creating an account, the user can select a merchant that also has an account with the payment service system.

To conduct cardless payment transactions with a merchant at the point of sale, the user can give consent to perform a cardless payment transaction with the merchant. After the user gives consent, the merchant can, without using a physical payment card, charge (in the case of credit cards) or debit (in the case of debit cards) the user’s financial account for items the user wants to buy. Because the user’s payment card is already on file with the cardless payment system, the user does not need to physically present a credit card to the merchant.

FIG. 1 is a schematic illustration of the architecture of an example system 100. The overall system 100 includes two user devices 102 and 103, a merchant device 104, and a payment service system 108 connected to a network, e.g., the Internet 106. The user device 102 is a computing device capable of running software applications. For example, the user device 102 can be a desktop computer, laptop computer, smartphone, or tablet computer. The merchant device 104 is also a computing device, capable of processing transactions. The merchant device 104 can be a mobile device, a server, a desktop computer, a laptop computer, a dedicated point-of-sale system, or other data processing apparatus. By using the payment service system 108, the user device 102 and merchant device 104 can conduct a payment transaction, for example a cardless or online payment transaction.

The merchant device 104 can communicate with the payment service system 108 using the network 106. Optionally, the user devices 102, 103 can also communicate with the payment service system 108 using the network 106. In addition, the user devices 102, 103 can communicate directly with the merchant device 104 using a short to mid-range communication technology, e.g. near field communication (NFC), Bluetooth, or Bluetooth Low Energy (BLE) technologies. In some implementations, the user devices 102, 103 can communicate directly with one another using a short to mid-range communication technology.

The payment service system **108** includes one or more servers **112**, at least some of which can handle secure transactions (e.g., a secure server), to processes all transactions between the user device **102** and merchant device **104**. In general, servers **112** can store public merchant information such as the merchant's address or phone number. The servers **112** can also be responsible for transferring or updating the user application to the user's mobile device or transferring or updating the merchant application to the merchant's computing device. In particular, the servers **112** can be responsible for sending information about merchants that have accounts with the cardless payment system to the user device **102**. The servers **112** also handle secure information such as credit card numbers, debit card numbers, bank accounts, user accounts, user identifying information or other sensitive information.

The payment service system **108** can communicate electronically with a card payment network **116**, e.g., Visa, Mastercard, or the like. The payment service system **108** can communicate with a computer system **116** of a card payment network, e.g., Visa or MasterCard. The payment service system **108** can communicate with a computer system **116** over the same network **106** used to communicate with the user device **102**, or over a different network. The computer system **116** of the card payment network can communicate in turn with a computer system **118** of a card issuer, e.g., a bank. There can also be computer systems of other entities, e.g., the card acquirer, between the payment service system **108** and the card issuer.

Before a transaction between the user and the merchant can be performed, the user must create a user account with the payment service system **108** and the merchant must create a merchant account with the payment service system **108**.

The user can sign up using a mobile application or using an online website, and can use the mobile device **102** or another computing device, e.g., a home computer. At some point prior to the transaction, a user application is downloaded to the user device **102**, e.g., through an application store. Creation of the user account can be handled through the user application, or through another application, e.g., a generic web browser. The user enters a name, account password, and contact information, e.g., email address. Before a transaction can be performed, the user also enters financial account information sufficient to conduct the transaction into the payment service system **108**. For example, in the case of a credit card account, the user can enter the credit card issuer, credit card number and expiration date into the payment service system **108**; the card validation value and mailing address may also be required. However, the financial account could also be associated with a debit card or pre-paid card, or another third party financial account.

In some implementations, the payment service system **108** requires additional personal identifying information before a transaction can be performed. For example, the payment service system **108** may require a photo of the user before a transaction can be performed. The photo of the user can be provided to the merchant at the point of sale so that the merchant can compare the photo to the person. In addition, the payment service system **108** can require a personal identification number (PIN) to be entered by the user. Other requirements can also be added to increase security. The data associated with a user account **114** can be stored at the servers **112**, e.g., in a database.

If the user is signing up with a mobile application, the user's financial account information can be entered by swiping the financial transaction card through a slot of a card

reader coupled to the mobile device. Alternatively, the user can enter in financial account information by typing in information at the mobile device **102**, selecting a card from an application on the mobile device, from an online entity, or others. In some implementations, another external application generates a receipt that is sent to the user. The receipt then includes a hypertext link that allows a user to easily create a user account in the cardless payment system. For example, activating the link in the receipt can automatically create a user account with a payment card prefilled with the card used in the receipt to reduce effort by the user. In effect, activating a new account using a receipt auto-verifies the user into the cardless payment system.

The merchant can sign up for an account using the merchant device **104** or another device. The merchant enters a name, account password, and contact information, e.g., email address, and physical location information, e.g., an address, into the payment service system **108**. The merchant can also provide other information, e.g., a list of goods or services available, operating hours, phone number, a small identifying image logo or mark, to the payment service system **108**. The data associated with the merchant account **114** can be stored at the servers **112**, e.g., in a database.

At some point prior to the transaction, a merchant application is downloaded to the merchant device **102**, e.g., through an application store. Creation of the merchant account can be handled through the merchant application, or through another application, e.g., a generic web browser.

Eventually, in order to receive funds from the transaction, the merchant will need to enter financial account information into the payment service system sufficient to receive funds. For example, in the case of a bank account, the user can enter the bank account number and routing number. However, the merchant's financial account can also be associated with a credit card account or another third party financial account. In addition, in some implementations, if the merchant has not entered the financial account information, the cardless payment processor can hold the received funds until the financial account information is provided.

FIG. 2 is a diagram **200** that illustrates customers, each with a customer device, at a merchant's place of business. Customers **205**, **210**, and **215** may be waiting to pay, sitting at a bar, waiting in line, browsing the merchant's store, or sitting at a table. Each customer is carrying a customer device **207**, **212**, or **217**, and each customer can provide payment to the merchant **220** through a cardless payment system, such as the cardless payment system **100** from FIG. 1. User devices **102** and **103** from FIG. 1 can be examples of customer devices **207**, **212**, and **217**.

The merchant device **222**, which is an example of merchant device **104** from FIG. 1, can measure the radio signal strength emitted from each customer device **207**, **212**, and **217**. For example, the merchant device **222** can measure the radio signal strength being emitted by customer device **207**. The radio signal emitted from a customer device will generally include a unique identifier that can be used to distinguish a particular customer device from other customer devices. The unique identifier will generally not include personally identifying information about the user, and may be updated on a frequent and rotating basis to mitigate the risk of spoofing or fraud.

In some implementations, the merchant device **222** may emit a radio signal. A customer device, for example, customer device **207**, may measure the strength of the radio signal emitted from the merchant device. The radio signal may include an identifier that allows the customer device **207** to identify that merchant device **222** is emitting the radio

5

signal. The customer device 207 may use the radio signal for a local calculation by a processor in the customer device 207. Alternatively, the customer device 207 may transmit the detected radio signal strength back to the merchant device 222.

The merchant device 222 can measure the radio signal strength for customer devices that are emitting a detectable radio signal for customer devices that are located within a particular distance of the merchant device. Each customer device may broadcast a radio signal to search for other devices that can communicate with the customer device. For example, customer device 207 may broadcast a Bluetooth signal to search for discoverable devices in the area. If the merchant device 222 is within range of the customer device 207 then then a transceiver in the merchant device 222 can detect the signal. In detecting the signal, the merchant device 222 can measure the strength of the signal.

The merchant device 222 may use the signal strength to determine a distance from the merchant device 222 to a customer device. Typically, when a customer device is closer to the merchant device 222, the signal strength detected by the merchant device is higher. For example, the merchant device 222 may measure the signal strength of customer device 207 to be 2 dBm, the signal strength of customer device 212 to be 4 dBm and the signal strength of customer device 217 to be 3 dBm. The merchant device 222 may then be able to calculate a distance from the merchant device to the customer device based on a signal strength and distance function. The merchant device 222 may calculate that the customer device 207 is five meters away, the customer device 212 is one meter away, and the customer device 207 is four meters away. The calculated distance is a singular scalar value, not a position. The calculated distance is a function of the detected signal strength and is not a triangulation of different signals.

One problem is that the signal strength may be attenuated because of physical barriers or electromagnetic interference. Sometimes a customer may have a customer device in a pocket or in a purse. When a customer device broadcasts a radio signal, the strength of the radio signal may be blocked when the signal passes through a customer's body or a customer's bag. For example, customer device 207 may be five meters from merchant device 222. When the customer device 207 is in the pocket of customer 205, the signal strength measured by the merchant device 222 may be 3 dBm. When the customer 205 is holding the customer device 207, the signal strength measured by the merchant device may be 4 dBm. Consequently, using solely the signal strength can lead to unreliable distance determination.

Each customer device includes a plurality of motion sensors that can measure and record the spatial movement of the customer device. The motion sensors may include an accelerometer, gyroscope, or other device used to measure motion. The motion sensors may provide data related to the six degrees of freedom, i.e., three rotational axes and three translational axes. For example, when a customer 205 removes the customer device 207 from the customer's pocket, the motions sensors of customer device 207 will detect the motion associated with that movement. If customer 210 drops the customer device 212, then the motion sensors of the customer device 212 will detect that motion. Further, while customer device 217 is not in motion, its motion sensors will indicate that fact.

The customer device may provide the data from the plurality of motion sensors to the merchant device 222. When a customer device and the merchant device 222 are both running an application for the cardless payment system

6

and the customer has chosen to conduct cardless financial transactions with the merchant 220, each device may recognize the other and may share information from the plurality of motion sensors. For example, customer 215 may have enrolled in the cardless payment system and installed the cardless payment application on customer device 217 and selected to do business with merchant 220. When customer device 217 is within range of merchant device 222, the customer device 217 may provide the data from the plurality of motion sensors to the merchant device 222. The customer device 217 may provide the data from the plurality of motion sensors at a regular rate, for example, every second. Alternatively, the customer device 217 may provide data from the plurality of motion sensors when the customer device 217 detects a significant change in one of the data points from the plurality of motion sensors.

The merchant device 222 can validate the distance calculated on the basis of the radio signal strength using the data from the motion sensors. Once the merchant 222 determines the distance between the merchant device 222 and a customer device and receives the motion sensor data, the merchant device 222 may use the motion sensor data to confirm the accuracy of the calculated distance.

In one example, the customer 205 may not be moving relative to merchant device 222. Based on the signal strength emitted from customer device 207 and measured by merchant device 222, the merchant device 222 calculates that customer device 207 is an initial distance, e.g., five meters, from merchant device 222. While the customer 205 is stationary and not moving the customer device 207, a person or an object moves between the customer device 207 and the merchant device 222. Consequently, the signal strength of customer device 207 measured by merchant device 222 when the person or object is between the customer device 207 and the merchant device 222 is less than before the person or object moved between the customer device 207 and the merchant device 222. With the reduced signal strength, the merchant device 222 calculates the customer device 207 to be a second, larger distance, e.g., seven meters, from the merchant device. The merchant device 222 receives motion sensor data from the customer device 207. The merchant device 222 uses the motion sensor data to determine that the customer device 207 has moved less than a threshold amount in the time that the calculated distance to the merchant device 222 increased. The threshold amount could be a predetermined amount, e.g., one foot, or the threshold amount could be a percentage of the change in distance. Accordingly, the merchant device 222 rejects the new distance value and validates the initial distance.

In another example, the customer 205 may not be moving relative to the merchant device 222. The customer 205 may be facing the merchant device 222 and holding the customer device 207 such that the customer device 207 has a clear line of sight to the merchant device 222. The merchant device 222 may calculate that the customer device 207 is an initial distance, e.g., five meters, from the merchant device 222 based on the measured signal strength. The customer 205 may rotate around such that the customer's body is between the merchant device 222 and the customer device 207. At this point, the merchant device 222 may detect a lower signal strength and calculate that the distance between the merchant device 222 and the customer device 207 is a second, larger distance, e.g., seven meters. The merchant device 222 receives motion sensor data from the customer device 207. The merchant device 222 uses the motion sensor data to determine that the customer device 207 has rotated in the time that the calculated distance to the merchant

device 222 increased. Accordingly, the merchant device 222 rejects the second, larger distance value and validates the initial value.

In another example, the customer 205 may be moving farther away from the merchant device 222. As the customer 205 is moving, the signal strength measured by the merchant device 222 decreases. The merchant device determines that the customer device 207 has moved from an initial distance, e.g., five meters, from the merchant device 222 to a second, larger distance, e.g., seven meters, from the merchant device 222 based on the signal strength. The merchant device 222 receives motion sensor data from the customer device 207. The merchant device 222 uses the motion sensor data to determine that the customer device 207 has moved laterally in the time that the calculated distance to the merchant device 222 increased. Accordingly, the merchant device 222 validates the second distance value.

In another example, the customer 205 may not be moving and may be an actual distance, e.g., five meters, away from the merchant device 222. The customer 205 may have the customer device 207 in the customer's back pocket. The merchant device 222 may calculate that the customer device 207 is an initial, calculated distance, e.g., seven meters, from the merchant device 222 based on the measured signal strength. The customer 205 may remove the customer device 207 from the customer's back pocket. At this point, the merchant device 222 may detect a higher signal strength and calculate that the distance between the merchant device 222 and the customer device 207 is a second, calculated distance, e.g., five meters. The merchant device 222 receives motion sensor data from the customer device 207. The merchant device 222 uses the motion sensor data to determine that the customer device 207 has moved vertically, e.g., thirty centimeters, in the time that the calculated distance to the merchant device 222 decreased. Accordingly, the merchant device 222 rejects the first calculated distance value and validates the second calculated distance value.

In another example, the customer 205 may not be moving and may be an actual distance, e.g., five meters, away from the merchant device 222. The customer 205 may have the customer device 207 in the customer's back pocket. The merchant device 222 may calculate that the customer device 207 is an initial, calculated distance, e.g., seven meters, from the merchant device 222 based on the measured signal strength. The customer 205 may remove the customer device 207 from the customer's back pocket. At this point, the merchant device 222 may detect a higher signal strength and calculate that the distance between the merchant device 222 and the customer device 207 is a second, calculated distance, e.g., five meters. The merchant device 222 receives motion sensor data from the customer device 207. The merchant device 222 uses the motion sensor data to determine that the customer device 207 has moved in a pattern similar to an "out of pocket motion profile." The "out of pocket motion profile" is consistent with the movement that the customer device 207 would travel when removed from a back pocket. The translational portion of the movement would be consistent with the path that a human hand, as limited by the shoulder and elbow, would take through space when removing an object from the person's back pocket. The rotational portion of the movement would be consistent with the rotation that a human hand would take when removing an object from the person's back pocket to in front of the person's face. Based on determining that the customer device 207 has moved in a similar pattern to the "out of pocket motion profile," the merchant device 222 rejects the first calculated distance value and validates the second

calculated distance value. In some implementations, the customer device 207 may determine locally on the customer device 207, that the customer device 207 is moving in a similar pattern to the "out of pocket motion profile" and transmit that information to the merchant device 222.

In another example, the merchant device 222 may compare motion data and signal strength data to reject improbable accelerations or speeds. For example, the merchant device 222 may measure the signal strength emanating from the customer device 207 and calculate the acceleration of the customer device 207 to be a measured acceleration rate, e.g., five meters per second squared. The merchant device 222 may receive motion data from the customer device 207 and calculate the acceleration of the customer device 207 to also be the measured acceleration rate, e.g., five meters per second squared. In this instance, because the measured acceleration rate that is based on the signal strength and the measured signal strength that is based on the motion data are within a threshold, the merchant device 222 uses the motion data to verify the measured acceleration rate that is based on the signal strength. In another example, the merchant device may measure the signal strength emanating from the customer device and calculate the speed of the customer device to be a measured speed, e.g., twenty meters per second. The merchant device 222 may receive motion data from the customer device 207 and calculate the speed to be a different measured speed, e.g., 0.1 meters per second. In this instance, because the measured speed that is based on the signal strength and the measured speed that is based on the motion data are separated by at least a threshold, the merchant device uses motion data to reject the measured speed that is based on the signal strength.

The merchant device 222 can generate a list of customers based on the distances from the merchant device. The merchant device 222 can identify the customer devices in the merchant's store who have enrolled in the cardless payment system and using the computed distances can generate a ranked list based on the validated distances to the merchant device 222.

In the example described above, the merchant device validated the distances using the motion sensor data. In some implementations, the customer device may compute the distance and validate or adjust the distance based on the data from the motion sensors. For example, instead of transmitting the motion sensor data to the merchant device 222, the customer device 205 may validate the distance locally on a processor in the customer device 205. The merchant device 222 computes the approximate distance to the customer device 205, transmits the approximate distance to the customer device 205, the customer device 205 validates or adjusts the approximate distance, and provides the validated or adjusted distance back to the merchant device 222. In some implementations, the merchant device 222 may emit a signal that the customer device 207 may use to compute distance based on the strength of the signal emitted from the merchant device 222.

In some implementations, the customer device may provide motion sensor data encoded in the radio signal that the merchant device 222 uses to compute the approximate distance to the customer device. For example, the merchant device 222 may confirm that the merchant device 222 is receiving the radio signal from the customer device 205. Instead of transmitting the motion sensor data separately from the Bluetooth signal that the merchant device 222 uses to compute approximate distance, the customer device 205 may encode the motion sensor data in the Bluetooth signal.

FIG. 3 is diagram of an example view of a user interface of an application installed on a merchant device. The user interface **300** includes a presentation of a ranking **305** of customers according to a distance between a customer device of each customer and the merchant device. The distance can be computed based on a signal strength measured by the merchant device for each user device and validated or adjusted based on motion sensor data.

The presentation includes a representation **320** for each customer, e.g. customer who is present in the merchant's store, has enrolled in the cardless payment system, and has selected to conduct financial transactions with the merchant. The representation **320** may include a customer's profile picture **322**, a customer's name **324**, and an indication of a distance **326** of the user device from the merchant device.

A user operating the merchant device can use the user interface **310** to process orders placed by customers, e.g. by selecting each customer from the ranking **305**. The user operating the merchant device can then enter items selected by the customer and then select an option that causes the merchant device to process the transaction, for example, as a cardless payment transaction that accesses the customer's account.

After conducting the payment transaction for a particular user, the merchant device can remove the customer's mobile device from consideration for future ranking by distance. In other words, the merchant device can flag an identifier of the customer device to indicate that the customer's payment transaction is finished and the customer device should not be ranked with other customer devices, even if currently located very near the merchant device. The merchant device can then automatically update the displayed listing of remaining customers. The merchant device may also recompute and validate distances between each customer device and the merchant device, e.g. by receiving new signal strength measurements and motion sensor data.

FIG. 4 is a flow chart of an example process **400** for computing and validating distances between devices. In general, the process **400** computes distances between a customer device and a merchant device. The process **400** will be described as being performed by a computer system comprising one or more computers, for example, the merchant device **104** as shown in FIG. 1 or the merchant device **222** as shown in FIG. 2.

The merchant device identifies the signal strength of a wireless signal between a customer device and a merchant device (**410**). The customer device may broadcast a wireless signal to search for other devices with which to communicate. The merchant device may receive this signal and measure a strength of the signal. The customer device may also broadcast an identifier for the customer device by encoding the customer identifier in the signal. For example, the customer may have a unique customer identifier for the cardless payment system. When the cardless payment application is running on the customer device, the customer device may encode the customer identifier in the broadcast signal. The merchant device can identify the customers based on the customer identifier. The wireless signal may be a Bluetooth signal, a Wi-Fi signal, or a similar type of wireless signal.

The merchant device determines an approximate distance between the customer device and the merchant device based on the signal strength (**420**). Typically, the lower the signal strength the farther away the customer device is from the merchant device. For example, if the signal strength for a first customer device is 3 dBm and the signal strength for a

second customer device is 1 dBm, then the first customer device may be closer to the merchant device than the second customer device.

The merchant device receives data from motion sensors on the customer device (**430**). The motion sensors may detect movement along the six degrees of freedom. The customer device may continuously provide the motion sensor data to the merchant device, for example, every second. Alternatively, the customer device may provide motion sensor data when one of the points of data changes more than a threshold. The motion sensor data may be provided over Wi-Fi or may be encoded in the signal used by the merchant device to measure signal strength.

The merchant device validates the approximate distance based on data from the motion sensors (**440**). The merchant device may use the data from the motion sensors to determine the movement of the customer device. As described in the examples above, the merchant device may determine whether the customer device has moved, rotated, moved laterally with respect to the merchant device, or moved vertically. The merchant device, based on determining the movement of the customer device, may validate the approximate distance or reject the approximate distance and validate the previous distance.

The merchant device generates a list of customers based on the distance from each customer device to the merchant device (**450**). The merchant device computes and validates the distances of each customer device that has signed up for the cardless payment system, has selected to transact business with the merchant, and is near the merchant device. The merchant device displays a list of the customers associated with each customer device and displays them on the merchant device.

FIG. 5 is a flow chart of an example process **500** for computing and validating distances between devices. In general, the process **500** computes distances between a customer device and a merchant device. The process **500** will be described as being performed by a computer system comprising one or more computers, for example, the user device **102** as shown in FIG. 1 or the customer device **207** as shown in FIG. 2.

The customer device identifies the signal strength of a wireless signal between a customer device and a merchant device (**510**). The merchant device may broadcast a wireless signal, e.g., to search for other devices with which to communicate. The customer device may receive this signal and measure a strength of the signal. The merchant device may also broadcast an identifier for the merchant device by encoding a merchant identifier in the signal. For example, the merchant may have a unique merchant identifier for the cardless payment system. The merchant device may encode the customer identifier in the broadcast signal. The customer device can identify the merchant based on the merchant identifier. The wireless signal may be a Bluetooth signal, a Wi-Fi signal, or a similar type of wireless signal.

The customer device determines an approximate distance between the customer device and the merchant device based on the signal strength (**520**). Typically, the lower the signal strength the farther away the customer device is from the merchant device. For example, if the signal strength detected by a first customer device is 3 dBm and the signal strength detected by a second customer device is 1 dBm, then the first customer device may be closer to the merchant device than the second customer device.

The customer device gathers data from motion sensors (**530**). The motion sensors may be located locally on the customer device. The motion sensors may detect movement

along the six degrees of freedom that consist of the three translational directions and the three rotational axes.

The customer device validates the approximate distance based on data from the motion sensors (540). The customer device may use the data from the motion sensors to determine the movement of the customer device. As similarly described in the examples above, the customer device may determine whether the customer device has moved, rotated, moved laterally with respect to the merchant device, or moved vertically. The customer device, based on determining the movement of the customer device, may validate the approximate distance or reject the approximate distance and validate the previous distance.

The customer device transmits the validated approximate distance to the merchant device (550). The merchant device may use the validated approximate distances received from several customer devices to generate a list of the customers associated with each customer device and display the list on the merchant device.

FIG. 6 is a diagram of an example graph 600 of signal strength and motion data. Graph 600 illustrates the measured signal strength and the computed movement of the customer device. Curve 610 represents the measured signal strength over time, and curve 620 represents the computed movement of the customer device over time. Between time T0 and time T1, the signal strength is constant at a first strength, e.g., A dBm, and the computed movement is zero. In this time period, the merchant device may calculate, based on the signal strength that the customer device is a first computed distance, e.g., three meters, from the merchant device. With the computed movement being zero, the merchant device may validate the first computed distance.

At time T2, the signal strength drops to a second strength, e.g., C dBm. At the same time T2, the signal strength remains constant and the computed motion is zero. At this time, the merchant device may calculate, based on the signal strength that the customer device is a second computed distance, e.g., five meters, from the merchant device. However, based on the motion data that indicated that the customer device did not move at or around time T2, then merchant device may reject the second computed distance and revalidate the first computed distance, e.g., three meters.

Between time T2 and T3, the signal strength rises to a third strength, e.g., B dBm and the computed motion rises to a particular speed, e.g., one meter per second. In this time period, the merchant device may calculate, based on the increase in the signal strength that the customer device is moving from the first computed distance to a third computed distance, e.g., three meters to four meters. Based on the motion data, the merchant device may determine that the customer device was moving between time T2 and T3, and may validate the third computed distance. In some implementations, the customer device may perform the above described calculations and comparisons locally on the customer device and transmit the validated distance to the merchant device.

Embodiments of the subject matter and the operations described in this specification can be implemented in digital electronic circuitry, or in computer software, firmware, or hardware, including the structures disclosed in this specification and their structural equivalents, or in combinations of one or more of them. Embodiments of the subject matter described in this specification can be implemented as one or more computer programs, i.e., one or more modules of computer program instructions, encoded on a non transitory computer storage medium for execution by, or to control the operation of, data processing apparatus. Alternatively or in

addition, the program instructions can be encoded on an artificially generated propagated signal, e.g., a machine generated electrical, optical, or electromagnetic signal, that is generated to encode information for transmission to suitable receiver apparatus for execution by a data processing apparatus. A computer storage medium can be, or be included in, a computer readable storage device, a computer readable storage substrate, a random or serial access memory array or device, or a combination of one or more of them. Moreover, while a computer storage medium is not a propagated signal, a computer storage medium can be a source or destination of computer program instructions encoded in an artificially generated propagated signal. The computer storage medium can also be, or be included in, one or more separate physical components or media (e.g., multiple CDs, disks, or other storage devices).

The operations described in this specification can be implemented as operations performed by a data processing apparatus on data stored on one or more computer readable storage devices or received from other sources.

The term “data processing apparatus” encompasses all kinds of apparatus, devices, and machines for processing data, including by way of example a programmable processor, a computer, a system on a chip, or multiple ones, or combinations, of the foregoing. The apparatus can include special purpose logic circuitry, e.g., an FPGA (field programmable gate array) or an ASIC (application specific integrated circuit). The apparatus can also include, in addition to hardware, code that creates an execution environment for the computer program in question, e.g., code that constitutes processor firmware, a protocol stack, a database management system, an operating system, a cross platform runtime environment, a virtual machine, or a combination of one or more of them. The apparatus and execution environment can realize various different computing model infrastructures, such as web services, distributed computing and grid computing infrastructures.

A computer program (also known as a program, software, software application, script, or code) can be written in any form of programming language, including compiled or interpreted languages, declarative or procedural languages, and it can be deployed in any form, including as a stand alone program or as a module, component, subroutine, object, or other unit suitable for use in a computing environment. A computer program may, but need not, correspond to a file in a file system. A program can be stored in a portion of a file that holds other programs or data (e.g., one or more scripts stored in a markup language resource), in a single file dedicated to the program in question, or in multiple coordinated files (e.g., files that store one or more modules, sub programs, or portions of code). A computer program can be deployed to be executed on one computer or on multiple computers that are located at one site or distributed across multiple sites and interconnected by a communication network.

The processes and logic flows described in this specification can be performed by one or more programmable processors executing one or more computer programs to perform actions by operating on input data and generating output. The processes and logic flows can also be performed by, and apparatus can also be implemented as, special purpose logic circuitry, e.g., an FPGA (field programmable gate array) or an ASIC (application specific integrated circuit).

Processors suitable for the execution of a computer program include, by way of example, both general and special purpose microprocessors, and any one or more processors of

any kind of digital computer. Generally, a processor will receive instructions and data from a read only memory or a random access memory or both. The essential elements of a computer are a processor for performing actions in accordance with instructions and one or more memory devices for storing instructions and data. Generally, a computer will also include, or be operatively coupled to receive data from or transfer data to, or both, one or more mass storage devices for storing data, e.g., magnetic, magneto optical disks, or optical disks. However, a computer need not have such devices. Moreover, a computer can be embedded in another device, e.g., a mobile telephone, a personal digital assistant (PDA), a mobile audio or video player, a game console, a Global Positioning System (GPS) receiver, or a portable storage device (e.g., a universal serial bus (USB) flash drive), to name just a few. Devices suitable for storing computer program instructions and data include all forms of non volatile memory, media and memory devices, including by way of example semiconductor memory devices, e.g., EPROM, EEPROM, and flash memory devices; magnetic disks, e.g., internal hard disks or removable disks; magneto optical disks; and CD ROM and DVD ROM disks. The processor and the memory can be supplemented by, or incorporated in, special purpose logic circuitry.

To provide for interaction with a user, embodiments of the subject matter described in this specification can be implemented on a computer having a display device, e.g., a CRT (cathode ray tube) or LCD (liquid crystal display) monitor, for displaying information to the user and a keyboard and a pointing device, e.g., a mouse or a trackball, by which the user can provide input to the computer. Other kinds of devices can be used to provide for interaction with a user as well; for example, feedback provided to the user can be any form of sensory feedback, e.g., visual feedback, auditory feedback, or tactile feedback; and input from the user can be received in any form, including acoustic, speech, or tactile input. In addition, a computer can interact with a user by sending resources to and receiving resources from a device that is used by the user; for example, by sending web pages to a web browser on a user's client device in response to requests received from the web browser.

Embodiments of the subject matter described in this specification can be implemented in a computing system that includes a back end component, e.g., as a data server, or that includes a middleware component, e.g., an application server, or that includes a front end component, e.g., a client computer having a graphical user interface or a Web browser through which a user can interact with an implementation of the subject matter described in this specification, or any combination of one or more such back end, middleware, or front end components.

The computing system can include clients and servers. A client and server are generally remote from each other and typically interact through a communication network. The relationship of client and server arises by virtue of computer programs running on the respective computers and having a client server relationship to each other. In some embodiments, a server transmits data (e.g., an HTML page) to a client device (e.g., for purposes of displaying data to and receiving user input from a user interacting with the client device). Data generated at the client device (e.g., a result of the user interaction) can be received from the client device at the server.

A system of one or more computers can be configured to perform particular operations or actions by virtue of having software, firmware, hardware, or a combination of them installed on the system that in operation causes or cause the

system to perform the actions. One or more computer programs can be configured to perform particular operations or actions by virtue of including instructions that, when executed by data processing apparatus, cause the apparatus to perform the actions.

While this specification contains many specific implementation details, these should not be construed as limitations on the scope of any inventions or of what may be claimed, but rather as descriptions of features specific to particular embodiments of particular inventions. Certain features that are described in this specification in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment can also be implemented in multiple embodiments separately or in any suitable subcombination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a subcombination or variation of a subcombination.

Similarly, while operations are depicted in the drawings in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Moreover, the separation of various system components in the embodiments described above should not be understood as requiring such separation in all embodiments, and it should be understood that the described program components and systems can generally be integrated together in a single software product or packaged into multiple software products.

In some cases, the actions recited in the claims can be performed in a different order and still achieve desirable results. In addition, the processes depicted in the accompanying figures do not necessarily require the particular order shown, or sequential order, to achieve desirable results. In certain implementations, multitasking and parallel processing may be advantageous.

What is claimed is:

1. A computer-implemented method comprising:
  - determining signal strengths of a plurality of wireless signals, wherein an individual wireless signal of the plurality of wireless signals is transmitted between a first transceiver of a first device and a second transceiver of another device of one or more other devices; based at least in part on the signal strengths:
    - determining an approximate first distance between the first device and a second device; and
    - determining one or more approximate second distances, wherein an individual second approximate distance of the one or more approximate second distances corresponds to a distance between the first device and a respective other device of the one or more other devices;
  - ranking (i) the approximate first distance between the first device and the second device, and (ii) each of the one or more approximate second distances; based at least in part on the ranking, and based at least in part on the approximate first distance satisfying a threshold, presenting, via a display of the first device or the second device, a first representation of a first user of the first device that, upon a selection of the first

15

representation, facilitates a first payment transaction between the first user and a second user of the second device;

at least partly responsive to the selection of the first representation, identifying at least one of a first user account of the first user at a payment service system or a second user account of the second user at the payment service system, wherein identifying the at least one of the first user account or the second user account is based at least in part on a user identifier encoded in a wireless signal transmitted by the first transceiver of the first device or the second transceiver of the second device;

identifying stored payment data, stored by the payment service system, associated with the at least one of the first user account or the second user account;

processing the first payment transaction based at least in part on the stored payment data; and

responsive at least in part on the processing of the first payment transaction, presenting, via the display of the first device, a second representation of a third user of another device of the one or more other devices that, upon selection of the second representation, facilitates a second payment transaction between the first user and the third user.

2. The computer-implemented method as claim 1 recites, wherein determining the approximate first distance includes validating the approximate first distance based at least in part on motion sensor data received from a plurality of motion sensors associated with at least one of the first device or the second device.

3. The computer-implemented method as claim 1 recites, wherein the plurality of wireless signals are associated with a short-range communication network.

4. The computer-implemented method as claim 2 recites, further comprising:

based on the motion sensor data from the plurality of motion sensors, determining at least one of horizontal movement, vertical movement, or rotational movement of at least one of the first device relative to the second device or the second device relative to the first device;

determine that the at least one of the horizontal movement, the vertical movement, or the rotational movement does not indicate that the approximate first distance is inaccurate; and

validate the approximate first distance based on determining that the at least one of the horizontal movement, the vertical movement, or the rotational movement does not indicate that the approximate first distance is inaccurate.

5. The computer-implemented method as claim 1 recites, wherein the first representation is associated with identifying information associated with the first user or the second user.

6. The computer-implemented method as claim 1 recites, wherein the first payment transaction is a cardless payment transaction.

7. The computer-implemented method as claim 1 recites, wherein the stored payment data comprises at least one of first financial account information associated with the first user or second financial account information associated with the second user.

8. The computer-implemented method as claim 1 recites, further comprising:

responsive at least in part on processing the first payment transaction, determining updated signal strengths of the plurality of wireless signals, wherein presenting the

16

second representation of the third user of the other device is based at least in part on the updated signal strengths.

9. The computer-implemented method as claim 8 recites, further comprising:

determining a device identifier associated with the other device, wherein presenting the second representation of the third user of the other device is further based at least in part on the device identifier.

10. The computer-implemented method as claim 8 recites, wherein presenting the second representation of the third user of the other device is further based at least in part on a re-ranking of the other devices.

11. A computer-implemented method comprising: determining signal strengths of a plurality of wireless signals, wherein an individual wireless signal of the plurality of wireless signals is transmitted between a first transceiver of a first device and a second transceiver of another device of one or more other devices; based at least in part on the signal strengths:

determining an approximate first distance between the first device and a second device; and determining one or more approximate second distances, wherein an individual second approximate distance of the one or more approximate second distances corresponds to a distance between the first device and a respective other device of the one or more other devices;

ranking (i) the approximate first distance between the first device and the second device, and (ii) each of the one or more approximate second distances;

based at least in part on the ranking, and based at least in part on the approximate first distance satisfying a threshold, presenting, via a display of the first device or the second device, a first representation of a first user of the first device that, upon a selection of the first representation, facilitates a payment transaction between the first user and a second user of the second device;

at least partly responsive to the selection of the first representation, causing one or more servers of a payment service system to identify at least one of a first user account of the first user at the payment service system or a second user account of the second user at the payment service system, wherein identifying the at least one of the first user account or the second user account is based at least in part on a user identifier encoded in a wireless signal transmitted by the first transceiver of the first device or the second transceiver of the second device;

causing the one or more servers of the payment service system to identify stored payment data, stored by the payment service system, associated with the at least one of the first user account or the second user account; causing the one or more servers of the payment service system to process the payment transaction based at least in part on the stored payment data; and

presenting, via the display of the first device or the second device, an indication associated with processing the payment transaction.

12. The computer-implemented method as claim 11 recites, wherein presenting the first representation is further based at least in part on determining that at least the second user has the second user account usable for performing cardless payment transactions with other users.

17

13. The computer-implemented method as claim 11 recites, wherein the payment transaction is a cardless payment transaction.

14. A system comprising:  
one or more processors; and  
computer-readable instructions that, when executed by the one or more processors, cause the one or more processors to perform operations comprising:  
determining signal strengths of a plurality of wireless signals, wherein an individual wireless signal of the plurality of wireless signals is transmitted between a first transceiver of a first device and a second transceiver of another device of one or more other devices;

based at least in part on the signal strengths:  
determining an approximate first distance between the first device and a second device; and  
determining one or more approximate second distances, wherein an individual second approximate distance of the one or more approximate second distances corresponds to a distance between the first device and a respective other device of the one or more other devices;

ranking (i) the approximate first distance between the first device and the second device, and (ii) each of the one or more approximate second distances;

based at least in part on the ranking, and based at least in part on the approximate first distance satisfying a threshold, presenting, via a display of the first device or the second device, a first representation of a first user of the first device that, upon a selection of the first representation, facilitates a payment transaction between the first user and a second user of the second device;

at least partly responsive to the selection of the first representation, causing one or more servers of a payment service system to identify at least one of a first user account of the first user at the payment service system or a second user account of the second user at the payment service system, wherein identifying the at least one of the first user account or the second user account is based at least in part on a user identifier encoded in a wireless signal transmitted by the first transceiver of the first device or the second transceiver of the second device;

18

causing the one or more servers of the payment service system to identify stored payment data, stored by the payment service system, associated with the at least one of the first user account or the second user account;

causing the one or more servers of the payment service system to process the payment transaction based at least in part on the stored payment data; and  
presenting, via the display of the first device or the second device, an indication associated with processing the payment transaction.

15. The system as claim 14 recites, wherein determining the approximate first distance includes validating the approximate first distance based at least in part on motion sensor data received from a plurality of motion sensors associated with at least one of the first device or the second device.

16. The system as claim 14 recites, wherein the plurality of wireless signals are associated with a short-range communication network.

17. The system as claim 15 recites, the operations further comprising:

based on the motion sensor data from the plurality of motion sensors, determining at least one of horizontal movement, vertical movement, or rotational movement of at least one of the first device relative to the second device or the second device relative to the first device; determine that the at least one of the horizontal movement, the vertical movement, or the rotational movement does not indicate that the approximate first distance is inaccurate; and

validate the approximate first distance based on determining that the at least one of the horizontal movement, the vertical movement, or the rotational movement does not indicate that the approximate first distance is inaccurate.

18. The system as claim 14 recites, wherein the first representation is associated with identifying information associated with the first user or the second user.

19. The system as claim 14 recites, wherein the payment transaction is a cardless payment transaction.

20. The system as claim 14 recites, wherein the stored payment data comprises at least one of first financial account information associated with the first user or second financial account information associated with the second user.

\* \* \* \* \*